SPATIAL PATTERNS OF WAVE SIGNATURES IN BEACHES IN ESTUARIES AND BAYS (BEBS) OF DIFFERENT TIDAL RANGES

Md. Yousuf Gazi, Geocoastal Research Group, The University of Sydney, mdyousuf.gazi@sydney.edu.au
Thomas E. Fellowes, Geocoastal Research Group, The University of Sydney, thomas.fellowes@sydney.edu.au
Tristan Salles, Geocoastal Research Group, The University of Sydney, tristan.salles@sydney.edu.au
Ana Paula da Silva, Geocoastal Research Group, The University of Sydney, ana.dasilva@sydney.edu.au
Nicolas Villacieros-Robineau, Instituto de Investigacións Mariñas (IIM), CSIC, Vigo 36208, Spain, nvrobineau@iim.csic.es
Ratneel Deo, Geocoastal Research Group, The University of Sydney, ratneel.deo@sydney.edu.au
Ana Vila-Concejo, Geocoastal Research Group, The University of Sydney, ana.vilaconcejo@sydney.edu.au

INTRODUCTION

Beaches in estuaries and bays (BEBs) are common geomorphic features that provide habitats, recreational resources, and coastal infrastructure protection buffers. These BEBs are usually influenced by wind and swell waves, tides, riverine effects, and boat wakes. BEBs typically experience lower wave energy compared to open coast beaches due to different geomorphological and geological conditions. BEBs morphology depends on the relative percentage of the swell, wind, and infragravity waves including low and high-energy events (Hegge et al., 1996). It should also be noted that BEBs geomorphology is also controlled by the tidal-range conditions and asymmetry of tidal currents (Dronkers, 1986).

Research related to coastal management often emphasizes sandy beaches primarily altered by tides and swells, but it often overlooks the BEBs. The absence of comprehensive knowledge about BEB morphodynamics poses a significant challenge in the context of climate change, intensifying both uncertainties and susceptibility. (Vila-Concejo et al., 2010). In this sense, the present study aims to identify the role of the variability of wave climate in the BEB's morphological evolution in micro and mesotidal environments. Our focus lies in determining the proportions of wind, ocean swell, and infragravity waves that collectively influence the wave characteristics of these BEBs.

STUDY SITES

This study considered BEBs in Pittwater Estuary, Sydney (Australia), which is a micro-tidal environment, as well as BEBs in Ría de Vigo (Spain), which is in a mesotidal setting. These BEBs vary in terms of their distance from the bay entrance, orientations, wave exposure, and unique patterns of storm-induced erosion and subsequent recovery. We focus on four specific beaches in Pittwater and four in Ría de Vigo. Great Mackerel (Figure 1) is the most exposed to swells among the Pittwater BEBs due to being situated on the western coastline. Following this, Station Beach is on the eastern shore within a protective barrier. Moving further into the estuary, Snapperman Beach and Sand Point Beaches are on the northern and southern sides of a prominent feature. On the other hand, the most exposed beach on the outer southern shore is Ladeira among Ría de Vigo BEBs, followed by Samil. Cesantes Beach is furthest from the entrance on the inner southern shore. Similarly, on the northern shore, the most exposed beach is Barra.

METHODS

Field measurements were taken at the 8 BEBs from both Pittwater and Ría de Vigo. RBR Solo3 pressure sensors were installed at ~0.35m depth to continually record hydrostatic pressure at a rate of 2 Hz. We have applied wind fetch calculation using the method modified for shallow enclosed waters by Young and Verhagen (1996) to determine the boundary between wind and swell waves. Then, we employed Spectral Analysis using the cutoff frequency to separate wind, swell, and infragravity waves. Then the relative contribution of these wave components in spatial dimension including their energy and direction characteristics was used to identify the wave signature.

RESULTS

Spectral analysis of the wave measurements indicates that swell waves are the most prominent wave type among all BEBs, followed by wind waves generated within the bays, and then infragravity waves. BEBs near the bay entrance are mainly influenced by swell waves, although their exposure depends on the offshore direction of the incoming swell. Conversely, BEBs located further from the bay entrance are more impacted by either wind waves due to the long wind fetch or swell waves dominating the wave spectra. Infragravity waves become significant compared to wind waves and swell only at the most sheltered BEBs, where there is limited wind fetch and the shallow areas have led to a swell dissipation. It was observed that the height of the infragravity waves is higher in the BEBs within microtidal environments compared to the BEBs in mesotidal environments. Hence, the spectral characteristics of waves exhibit significant variability among BEBs within the same bay making them a valuable tool for examining the morphodynamics of BEBs. As the wave signatures translate into different profile morphotypes, this will also help to explain the spatiotemporal evolution of BEBs profiles.

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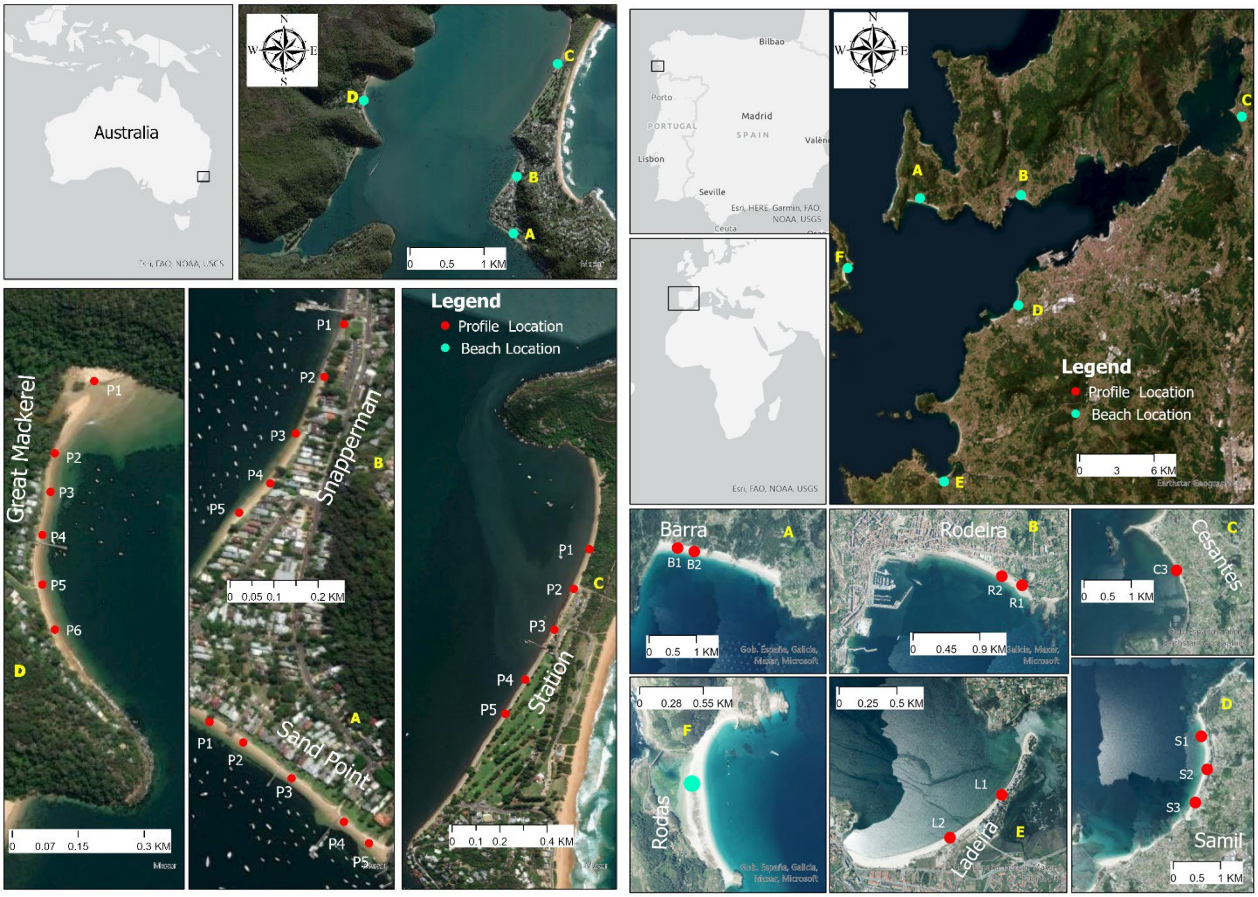

Figure 1. Sites map in the Pittwater Sydney (Left) and Vigo, Spain (Right). Showing the BEBs location in the Bay, location of beach profiles and groins, and pressure transducers.